Agriculture issues: usage of oats and alfalfa

Business, Strategy

The Dynamics of Interspecific Competition between Oats and Alfalfa

Introduction

There exists an immense set of complex interactions between organisms that exerts profound influences on diverse communities and greatly affect their ability to develop and remain established. These interactions take on a number of forms, from being mutually beneficial, like mutualism, to being mutually harmful, like competition. As competition is an interaction that harms both organisms, yet it is an incredibly commonplace occurrence that often establishes the dynamic of many ecological communities, it is of particular interest in the field of agriculture. The fundamental idea behind ecological competition is that it is over a limiting resource, such as nutrients, water, light, and/or pollinators. Competition can be interspecific – between two organisms of different species – or intraspecific – between two organisms within the same species. This interaction can greatly influence individual plants as well as community composition: for example, changes in species behavior as a result of competition may occur, such as resource partitioning, causing inferior competitors to look for other resources in order to survive. However, these species may be unable to relocate or find alternative sources of food, water, or nutrients, causing them to die out because they are limited by the same resource or resources as the superior competitor. This operates under the Competitive Exclusion Principle: two species that are limited by one or more of the same resources cannot coexist in the same space. To investigate these various types of potential interactions, oat plants were

examined, grown both alone and with alfalfa plants to observe how alfalfa may help or harm growth.

Materials and Methods

4 different pots were prepared for this experiment: 2 placed in full sun, and 2 in partial shade. In each set, one pot contained 50 oat seeds alone; the other contained 25 oat seeds as well as 25 alfalfa seeds. The pot size, amount of water, and greenhouse growing conditions were all kept constant between experimental groups. Plant length and weight were recorded after 2 months of growth, using above-ground length and biomass as a measure of plant success.

The pot with 50 oats served as an experimental condition with which to compare the pot with 25 oats and 25 alfalfa to uncover the nature of their interaction. These combinations would reveal if oats grow better alone or in the presence of alfalfa, as there is evidence to suggest alfalfa may provide important nutrients such as nitrogen to neighboring plants (Vasse, Billy, & Truchet, 1993). However, there is also literature discussing the use of oats as a cover crop to establish alfalfa, as it has been shown to quickly outcompete weeds; because of this, it is also plausible the oats would grow less successfully with alfalfa (Lanini, Orloff, Vargas, & Orr, 1992). Differing light conditions would demonstrate whether the pattern of interaction changes when light conditions change, and reveal what conditions these plants may prefer as well as whether a specific lighting becomes limiting in particular situations.

Results

In all conditions, the interaction between oats and alfalfa was positive for oats: compared to when grown alone, in every case oats grew taller with more biomass when planted with alfalfa. In full sun in the pot containing 50 oat seeds, an average of 42. 1 seeds germinated to become adults. As seen in Figure 1, the average height of these plants was 302. 2 mm. In the pot containing 25 oat seeds and 25 alfalfa seeds, an average of 21. 5 oat seeds grew to adulthood. The average height of these plants was 350. 7 mm. Figure 2 depicts the average weights of the oat plants: in full sun, oats in the 50 oats pot weighed 597. 6 mg, on average. In contrast, oats in the 25 oats/25 alfalfa pot weighed 851. 9 mg, on average. For both average length and weight of the oat plants in full sun, the results between those grown alone and with alfalfa were statistically significant at the 5% level: for average length, the p-value was 0. 027, and for average weight, the p-value was 0. 032. Overall, the difference in success between oats grown alone and in the presence of alfalfa was strongly significant.

In partial shade in the pot containing 50 oat seeds, an average of 43. 4 seeds grew successfully; this number was 21. 6 in the pot containing 25 oat seeds and 25 alfalfa seeds. As seen in Figure 1, the average height of the oats in the 50 oats pot in partial shade was 291. 2 mm, and the average height of the oats in the 25 oats/25 alfalfa pot in partial shade was 348. 8 mm. Figure 2 shows the average weight of the oat plants: in partial shade, oats in the 50 oats pot weighed 500. 5 mg, on average. Oats in the 25 oats/25 alfalfa pot weighed 829. 3 mg, on average. Just as was the case in full sun, for both length and weight, the difference between oats from the 50 oats pot and

oats from the 25 oats/25 alfalfa pot was statistically significant at the 5% level: for average length, the p-value was 0. 000; for average weight, the p-value was 0. 001. Overall, these differences were extremely significant.

Between the two lighting conditions, in the 50 oats pots, the p-value for the difference between full sun and partial shade was 0. 000 for both average length and weight, proving to be extremely significant at the 5% level. However, in the 25 oats/25 alfalfa condition, the p-value was 0. 666 for average length, and 0. 183 for average weight. Therefore, the results between full sun and partial shade for the 25 oats/25 alfalfa pots were not statistically significant at the 5% level.

Discussion

It is clear in this experiment that the competitive interaction occurring is interspecific between oats and alfalfa. Though these plants could be competing for a number of the same resources, the most plausible explanation is that they are competing for nitrogen, as it is well-known that alfalfa roots house Rhizobium meliloti bacteria which fix nitrogen for the plant (Vasse, Billy, & Truchet, 1993). Combined with the fact that oats are very capable of outcompeting other plants for resources, it is very likely oats outcompeted alfalfa for this nutrient as well as others, causing them to grow better under both light conditions in the presence of alfalfa (Lanini, Orloff, Vargas, & Orr, 1992). Though there is no significant difference in average length and weight of oats planted in the 25 oats/25 alfalfa pots between different light conditions, oats in the 50 oat pots grew significantly better in full sun as opposed to partial shade. This suggests that when nutrients like

nitrogen are not abundantly available for oats, sunlight may become a limiting resource.

Another factor that is likely to have played a role in the competitive success of oats is the size of the seeds. Evidence suggests that plants originating from “ heavy” seeds are stronger competitors; in this case, while alfalfa seeds were approximately 2 mm in length, oat seeds were 25-30 cm in length, and so it is logical that oats may be naturally better competitors (Houssard & Escarré, 1991). In addition, although oats and alfalfa generally have similar germination times depending on soil conditions, it is possible that oats are capable of releasing chemicals which delay the germination of alfalfa or have an ability to emerge more rapidly when a potential competitor is present. However, even though oats may dominate in this controlled interaction, they do not normally dominate in natural communities. This is for a variety of reasons, such as variations in environmental conditions, like natural disasters, disease, and predators, which impact organisms regardless of their ability to compete. There is also the need for diversity in the use of soil – monocultures deplete soils of nutrients and other resources, making the plants more susceptible to threats like disease. Finally, superior competitors may not always find the resources they need to best survive, even if they are better equipped to find and utilize these resources.

Though many replications of the experiment were performed, limitations and the potential for error still exist. For example, alfalfa seeds need to be planted about 1/4-1/8 inch deep; if they were not planted accordingly, they may not have grown as well. Because the plants were grown in stable

conditions, there is also a question of translatability to real-world conditions, as a greenhouse does not mimic the varying conditions which exist in a natural environment. There was also no potential for weeds to grow in this controlled environment, a factor that a “ companion crop” like oats would provide protection against, so these potential capabilities were unable to be observed. Finally, although above-ground length and weight of the adult plants was used as a measure of plant success and thus competition, this method may not account for other markers of plant success, such as the extensive roots systems of both oats and alfalfa. This very likely impacted the results as well.

Overall, this experiment provides evidence that is important for those in agriculture to consider. For example, although there is much literature suggesting the use of oats as a companion crop to aid in establishing alfalfa, this experiment reveals that oats may actually take away nutrients from the crop with which they were planted – in this case, alfalfa may actually be harmed more than helped by the presence of oats. If alfalfa is not the main crop, however, it may not be completely disadvantageous that biomass is reduced in these plants when planted with oats. Research suggests that this reduction in biomass is associated with reduced densities of certain pests like Empoasca fabae, possibly reducing the need for active pest management and making them helpful as companion crops themselves (Lamp, 1991). It is clear that when growing oats as a monoculture, lighting becomes a limiting resource, emphasizing the importance of full sunlight exposure when growing these plants as well.